QUALITY ASSESSMENT OF CATTLE MILK IN ADEA BERGA AND EJERIE DISTRICTS OF WEST SHOA ZONE, ETHIOPIA

M.Sc. THESIS

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I hereby certify that I have read and evaluated this Thesis entitled **"Quality Assessment of Cattle Milk in Adea Berga and Ejerie Districts of West Shoa Zone, Ethiopia''** prepared under my guidance by **Saba Haile**. I recommend that it be submitted as fulfilling the Thesis requirement.

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DEDICATION

I dedicated this thesis to my father **HAILE LEMMA,** and my mother **EHTE DEGU** for all love they have given me and their dedicated partnership in the success of my life.

STATEMENT OF THE AUTHOR

By my signature below, I declare and affirm that this Thesis is my own work. I have followed all ethical and technical principles of scholarship in the preparation, data collection, data analysis and compilation of this thesis. Any scholarly matter that is included in the Thesis has been given recognition through citation.

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BIOGRAPHICAL SKETCH

Saba Haile, the author, was born in Addis Ababa, 1984. She was completed Elementary Education at Jonihef Kendi and Edget Behbret Elementary School in 1999. She pursued her Secondary education and then completed preparatory at Shimels Habte Senior Secondary School and Keftegna 4 T.V.E institute in 2003. Then, she joined Haramaya University, College of Agriculture, in 2004, and graduated with B.Sc. degree in Agriculture (Animal Science) in 2006.

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ACRONYMS AND ABBREVIATIONS

AGP	Agricultural Growth Program
AI	Artificial Insemination
ASSP	Agricultural Sector Support Program
CC	Coliform Count
CFU	Colony Forming Units
CSA	Central Statistics Authority
DMRT	Duncan Multiple Range Test
EIAR	Ethiopian Institute of Agricultural Research
EMDIDI	Ethiopian Meat And Dairy Industry Development Institution
FAO	Food And Agricultural Organization of the United Nations
GDP	Gross Domestic Product
GLM	General Linear Model
HARC	Holleta Agricultural Research Center
HPA	Health Protection Agency
IFCN	International Farm Comparison Network
LIVES	Livestock and Irrigation Value-Chains For Ethiopian Smallholders
MOA	Ministry of Agriculture
SNV	Netherlands Development Organization
SPCA	Standard Plate Count Agar
TBC	Total Bacterial Count
TS	Total Solid
VRBA	Violet Red Bile Agar

TABLES OF CONTENTS

LIST OF TABLES

LIST OF FIGURES IN THE APPENDIX

LIST OF TABLES IN THE APPENDIX

Appendix Table Page

QUALITY ASSESSMENT OF CATTLE MILK IN ADEA BERGA AND EJERIE DISTRICTS OF WEST SHOA ZONE, ETHIOPIA

ABSTRACT

The objective of the study was to assess the hygienic handling practices, microbial as well as chemical composition of fluid milk in Adea Berga and Ejerie districts. A total of 180 smallholder producers, two dairy cooperatives, one dairy cooperative union, two milk processors and ten consumers were interviewed to collect the required information using a semi-structured questionnaire and focused group discussions. Survey works includes: Barn type and cleaning practices, hygienic condition of the milker and cows during milking, source of water used for cleaning purpose (udder, milker and milk utensils), type of milking container, fluid milk quality test methods, marketing system and major milk quality constraints. Preliminary quality tests and laboratory analysis were carried out to determine the P^H level, Microbial quality and chemical composition. A total of 90 milk samples were collected and analyzed. About 32.2% of milk samples were checked with alcohol test positive; while 18.8% of the samples were positive to clot-on-boiling test. The specific gravity of milk samples were in the range of 1.024 to 1.032 in Ejerie district and 1.022 to 1.031 in Adea Berga district. The normal Specific gravity of milk ranges from 1.026 to 1.032. The overall mean value of fat, protein and Total solid (TS) were 3.52, 3.09 and 12.19, respectively. Fat percent was significantly different ($P<0.05$) among different source of sampling points. The highest milk fat content value was recorded at Adea Berga district (3.94). *Overall mean total bacterial counts and coliform counts were 6.98±0.17, 4.84±0.10 log cfu/ml and significantly different b/n sites ($P<0.05$). The highest coliform (6.64 cfu/ml) and total bacteria counts (10.69 cfu/ml) were observed at consumers level. In general the result indicated that milk samples collected from smallholder milk producers, dairy cooperatives, dairy cooperative union, milk processor and consumers were subjected to microbial contamination and does not meet the international milk quality standard. Therefore, adequate sanitary measures should be taken at all stages from production to consumer level.*

Key Words:- *Milk quality, Milk marketing*

1. INTRODUCTION

Milk is the most popular food for human consumption and contains numerous nutrients such as water, fat, protein, lactose, minerals and vitamins (Walstra *et al*., 2006). It is the major source of regular income for Smallholder milk producers because it is produced and sold daily (Dugdill *et al,* 2013*)*. Besides its benefit, it is serves as an excellent growth medium for a wide range of microorganisms (Walstra *et al*., 2006). Bacterial contamination of raw milk can be originated from three main sources; within the udder, exterior to the udder and from the surface of milking materials, milk handling and storage equipments. Similarly, the surrounding air, feed, soil, feces and grass are also possible sources of contamination (Parek and Subhash, 2008; Torkar and Teger, 2008). If the hygienic handling of milk is not secured, milk could be turn to unsafe for direct consumption or unfit for further processing to more stable products (O'Connor, 1994).

Quality milk implies the milk which is free from pathogenic bacteria and harmful toxic substances, free from sediment and extraneous substances, of good flavor, with normal composition, adequate in keeping quality and low in bacterial counts (Khan *et al.,* 2008). Consumers need clean, wholesome and nutritious food that is produced and processed in a sound sanitary manner and free from pathogens. Hence, quality milk production is necessary for fulfilling consumers' demand (Khan *et al.,* 2008). To sell raw milk directly to consumers or to a processing factory, it must be handled hygienically and remains fresh and capable of being heated without curdling. Hygienic milk handling includes; using clean equipment, maintaining a clean milking environment, observing good personal hygiene and preserving the quality of milk during storage and transportation to the consumer or processing plant (Kurwijila, 2006). Milk quality should not be ignored at all stages of the dairy value chain from farm to table. As the bacterial quality of raw milk is important to product shelf-life, flavor and product yield, it is important that dairy enterprises should strive to obtain the highest quality raw material possible from their own farm as well as their suppliers. It is therefore essential to produce best quality raw milk in the dairy farm in order to manufacture milk products of acceptable quality (Zelalem, 2012).

In Ethiopia milk produced at smallholder farm is marketed without quality control measures. Hygienic control of milk and milk products is not usually conducted on routine bases. Apart from this, door-to-door raw milk delivery in the urban and peri-urban areas is commonly practiced with virtually no quality control at all levels (Godefay and Molla, 2000). Although, properly operational formal marketing and grading system targeted towards relating quality of products to market price is not well established, provision of milk and milk products of good hygienic quality is desirable from consumer's health point of view (Zelalem, 2012).

On the other hand, the Chemical composition, particularly milk fat content is used as quality test (Zelalem, 2010). The nutritional as well as the economic value of milk is directly associated with its solids content. The higher the solids content better its nutritional value and more of a milk product can be made (Pandy and Voskull, 2011). Protein content being one of main quality determining criteria applied to milk payment to producers in many countries where others are priced according to fat and solids-non-fat composition (FAO, 2004).

Information on the microbial and chemical composition of milk was essential to understand the quality of marketed milk supply. Previous research works mainly focused on microbial quality of fluid milk and very few studies were reported in both microbial and chemical composition at smallholder milk producer and dairy cooperatives. Therefore, the purpose of this research study was conducted to assess the quality of fluid milk in terms of its microbial and chemical compositions from smallholder producer up to consumer level in the study areas.

Objectives

- To assess the hygienic handling practices, microbial properties and chemical composition of marketed milk supplied from Adea Berga and Ejerie districts of West Shoa zone.
- To identify major whole milk quality constraints in the study areas.

2. LITERATURE REVIEW

2.1. Milk Production in Ethiopia

Ethiopia possesses the largest livestock population in Africa. Recent estimates indicated that the country have about 50.9 million heads of cattle, 24.06 million goats, 25.5 million sheep and 2.3 million camels (CSA, 2010). Milk production system can be categorized based on agro-ecology, socio-economic structures of the population and type of breed and species used for milk production can be classified into two major systems, namely rural dairy system (pastoralists, agro-pastoralists, and mixed crop–livestock producers) and urban and peri-urban dairy systems (Getachew and Gashaw, 2001). Milk production depends on mainly indigenous livestock genetic resources dominated by small holder farmers specifically on cattle, goats and camels. The indigenous breeds accounted for 99.19 percent, while the hybrids and pure exotic breeds were represented by 0.72 and 0.09 percent, respectively (Zelalem *et al.,* 2011). Milking cows in the traditional sector have an average lactation length of 190 days and an average milk yield 1.9 liters per day excluding the calf has suckled (MOA, 2005). The total annual national milk production in Ethiopia received from 9.6 million dairy cows and the product is estimated to be 2.9 billion liters which is, 1.69 liters yield per cow per day on average (FAO, 2010).

2.2. Sources of Microbial Contamination of Milk

The common predisposing factors of milk contamination by microorganisms are milking environment, cows, milking personnel, milking equipments, and water (Mbabazi, 2005).

2.2.1. Milking environment

Maintaining the sanitary condition of the milking area is important for the production of good quality milk (Zelalem, 2010). Dirty milking places tend to breed flies, which may fall in milk causing contamination and thus spoilage may occur (Mbabazi, 2005). When a cow urinates or defecates in the course of milking some of its urine or dung particles may drop into the milk (Mbabazi, 2005).

2.2.2. Cow (Udder)

Cleaning the udder of cows before milking is one of the most important hygienic practices required to ensure clean milk production (Zelalem, 2010). This is important since the udder of the milking cows could have direct contact with the ground, urine, dung and feed refusals. Cleaning and removal of soil particles, bedding material and manure from the udder and flanks is necessary to prevent the entry of many types of bacteria into the milk (O'Connor, 1995). Udder washing with clean water and drying using hand towels reduces milk contamination by transient bacteria located on the udder (Robert, 1996). Special care must be given to the cloths used for cleaning the udder. The re-use of cloths for cleaning and sanitizing may result in re-contamination of the udder. It is therefore recommended that separate cloths be used for cleaning and sanitizing and, if possible, each cloth should be used for one cow only (O'Connor, 1995). Not washing the udder before milking can impart possible contaminants into the milk. A maximum reduction of teat contamination of 90 % can be achieved with good udder preparation before milking. This depends on the initial level of contamination and the way of udder preparation. So with high initial contamination levels this 90 % reduction might not be reached (Murphy, 1996).

2.2.3. Milker

Milk handling personnel (milker) may contribute various organisms including pathogens especially when they are careless, uninformed, or willfully negligent, directly to milk (Ashenafi, 1994). Organisms may drop from hands, clothing, nose, and mouth and from sneezing and coughing. It is important for milk men to be in good health so that they can be a source of infectious diseases such as tuberculosis (Kurwijila, 1998).

2.2.4. Milking equipments

Poorly cleaned and sanitized milking utensils may be the source of many microorganisms (Banwart, 1989). Milk drops left on the surface of milking equipments act as excellent media for the growth of a variety of bacteria (Bramley and McKinnon, 1990). Milk equipment is not properly cleaned and sanitized after use. Milk residues left on equipment and utensil surfaces provide nutrients to support the growth of many microorganisms, including pathogens (Bryan, 1983). In case cracked milking equipments large number of bacteria enter and grow in the cracks, are difficult to clean (Thomas *et al.*, 1966). The bacterial load of milk increases during transportation and if the transportation equipment is not appropriate the bacterial counts increase causing spoilage before milk reaches its destination (Grillet *et al.*, 2007). Milking equipment should be easy to clean. Aluminum and stainless steel equipment are mostly preferred (Zelalem, 2010).

2.2.5. Water

Water serves as primary sources of microorganism's contamination (Mbabazi, 2005). If Water is obtained from an open water supply care should be taken to prevent drainage that may contain human feces and other contaminants gaining entry into the source (Jay, 1992).

2.3. Control Measures of Microbial Contamination in Raw Milk

Cooling: To prevent or retard growth of bacteria in milk and to maintain its quality for domestic consumption or during transport to the processing plant, it is essential to cool the fresh milk as quickly as possible (O'Connor, 1995). Prompt cooling or chilling of milk at a temperature of 5°C or below is necessary to minimize microbial growth and prevent milk quality deterioration during handling, storing and transporting before the raw milk being processed. In order to facilitate bulking of raw milk supply and transport the incoming milk, refrigeration facilities are provided at points of collection and transport means to maintain the temperature as much as possible (Getachew *et al.,* 2008). In the tropical countries of Africa with high ambient temperatures, lack of refrigeration facilities at the farm and household level imply that raw milk will acidify very fast (Godefay and Molla, 2000). Therefore the collection systems must be designed to move the milk to the cooling and/or processing center in shortest possible time. In addition every effort should be made to use available systems such as water cooling, air circulation or shaded areas to reduce milk temperature (Dello Castillo, 1990).

Boiling: It is the easiest and most practicable method of making milk safe in every home. As soon as raw milk is produced or delivered, it should be boiled. Boiling involves raising the temperature to the boiling point and maintaining at this temperature for a few minutes. Then the milk should be cooled immediately. The temperature should be maintained below 10ºc. Since this may be impracticable at home, preferably the milk must be consumed as soon as possible after cooling and not an extended period of time after it has been boiled and cooled (Gebra-Emanuel, 1997, Linton, 1982).

Pasteurization: it is the main safeguard against pathogenic organisms in milk. The combination of pasteurization, care in production and processing, and improved storage has resulted in relatively safe milk supply. Milk borne diseases like tuberculosis, diphtheria, and scarlet fever have been practically eradicated. Also, the shelf-life of milk has been increased from a few days to a few weeks (Vasavaoa and Smith, 1987).

2.4. Microbial Tests of Raw Milk

Clot on boiling test*:* This is one of the oldest tests for abnormal acidity levels in milk, which is brought about by too much acid in milk (pH<5.8). The test is performed by boiling a small amount of milk in a spoon, test tube or any other suitable container. If there is coagulation or precipitation, the milk fails the test. The test is not sensitive to slightly sour milk (O'Connor, 1995; Draaiyer *et al*, 2009).

Alcohol test*:*-The test is quick, simple and is used as a screening test. It is based on instability of the proteins when the levels of acid and/or rennet are increased and acted upon by the alcohol. Also increased levels of albumen (colostrum milk) and salt concentrates (mastitis) results in a positive test. The test is done by mixing equal amounts of milk and 68% ethanol (usually 2ml) in a small bottle or test tube. If the tested milk is of good quality, there will be no coagulation, clotting or precipitation upon shaking (O'Connor, 1995, Draaiyer *et al*, 2009). The alcohol test can detect milk whose pH is 6.4 or lower and is more sensitive than the clot-on-boiling test, which only detects milk pH levels of 5.8 and below. Colostrums and mastitis milk may give a positive alcohol test (Kurwijila, 2006)

Standard plate count: The standard plate count is generally accepted as the most accurate and informative method of testing bacteriological quality of milk (Kurwijilla *et al.*, 1992; Godefay and Molla, 2000). The total plate count of microbes in milk provides useful general information on the microbiological quality of milk. Total or aerobic plate count shows only the mesophillic aerobic organisms as incubation is done under normal atmospheric conditions at 35°C for 48 hours (Jay, 1992). The number of bacteria in aseptically drawn milk varies from animal to animal and even from different breasts of the same animal. On average, aseptically drawn milk from healthy udders contains between 500 and 1000 bacteria ml/l. High initial counts (more than 10^5 bacteria ml/1) are evidence of poor production hygiene (O'Connor, 1994).

Coli form bacteria*:* Coli forms are aerobic or facultative anaerobic, Gram-negative, non-spore forming rods that ferment lactose to produce gas when incubated on agar for 48 hours at 35°C (FAO, 1986). Coli forms are important mastitis pathogens (Hogan and Smith, 2003) and are widely distributed in the farm environment (Hogan *et al.*, 1989; McKinnon *et al.,* 1990; Sanderson *et al.*, 2005). Coliform count (CC) is a non regulated test that has been used historically to assess milk production practices such as milk refrigeration, milking machine sanitation, and pre milking udder hygiene (Guterbock and Blackmer, 1984; Davidson *et al.*, 2004). Coli form organisms contaminate raw milk from unclean milker's hands, improperly cleaned and unsanitized or faulty sterilization of raw milk utensils especially churns, milking machines, improper preparation of the cow's flecks or dirt, manure, hair dropping in to milk during milking, udder washed with unclean water, dirty towels and udder not dried before milking(Ombui *et al.*, 1995). The presence of coli form organisms in milk indicates unsanitary conditions of production, processing or storage. Hence their presence in large number in dairy products is an indication that the products are potentially hazardous to the consumers' health (Godefay and Molla, 2000). Coliform count provides an indication of unsanitary production practices and/or mastitis infection. A count less than 100 Colony Forming Units (CFU)/ml are considered acceptable for milk intended to be pasteurized before consumption. Counts of 10 CFU/ml or less are achievable and desirable if raw milk will be consumed directly (Ruegg, 2003).

2.5. Microbial Properties of Raw Whole Milk in Ethiopia.

Earlier researches conducted in different parts of the country revealed that the microbial counts of milk and milk products produced and marketed are generally much higher than the acceptable limits (Zelalem, 2010). These were evidenced by milk collected form smallholder producers in Southern Ethiopia the total bacterial count (TBC) reported by Abebe *et al.* (2012) 9.82 log cfu/ml in Gurage zone, Asaminew and Eyassu, (2010) 7.58 log cfu/ml in Bahir Dar Zuria and Mecha districts,; and Solomon *et al.* (2013) 7.07 log cfu/ml in Debre Zeit town, Ethiopia.

Other research findings also reported similar values of aerobic mesophilic counts milk sampled from udder, milking bucket, collection center, milk vending shops and cafeteria is range between 7.28 and 10.28 logcfu/ml (Godefaye and Molla, 2000; Haile *et al.*, 2012). In all cases increasing trend of counts as the milk passed through udder, milking bucket, collection centers and upon arrival at the processing plant. This could be due to improper handling, storage and transport time after the milk leaves the dairy farms. Milk produced under hygienic conditions from healthy cows should not contain more than 4.69 log cfu/ml (O' Connor, 1994).

However, raw milk samples from different part of the country TBC counts greater than the counts which is given by international standard set for minimum acceptable level of bacterial count (10^5 cfu/ml) in milk (IFCN, 2006). In other words, the above indicated count of milk samples collected from the country were considered to be below the standard set for good quality milk. This implies that the sanitary conditions in which milk has been produced and handled are substandard subjecting the product to microbial contamination and multiplication.

As indicated by Chambers (2002) total bacterial count is a good indicator for monitoring the sanitary conditions practiced during production, collection, and handling of raw milk. Hence training of milk handlers about hygiene can significantly reduce the bacterial load in milk. A good example worth mentioning is a reduced total bacterial count observed in milk sampled from farmers who received training on hygienic milk production and handling, and who used recommended milk containers as compared to that produced by the traditional milk producers (Rahel, 2008).

Coliform count, on the other hand, is especially associated with the level of hygiene during production and subsequent handling since they are mainly of fecal origin (Omore *et al*., 2001). Previous workers reported similar values of coliform counts in raw cow milk sampled from different part of the country that range between 4.03 log cfu/ml to 6.57 log cfu/ml (Fekadu, 1994; Alganesh, 2002; Zelalem and Faye, 2006; Asaminew and Eyassu, 2010).

Even if, it is not practical to produce milk that is always free of coliforms. Their presence in raw milk may therefore be tolerated. However, if present in large numbers, say over 100 coliform organisms per milliliter of raw milk, it means that the milk was produced under improper procedures (Walstra *et al*., 2006). Hence their presence in large number in dairy products is an indication that the products are potentially hazardous to the consumers' health (Godefay and Molla, 2000).

2.6. Chemical Composition of Milk

Chemical composition, particularly milk fat content is used as quality test. The solid constituents of milk make an important food item from both nutritional as well as processing point of view. Milk fat and protein are most important components of different varieties of most shelf stable milk products. It is therefore very important to determine the major chemical compositions of milk as it is the basis of further processing into more shelf stable products. Moreover, knowledge of the total solids and solids-not-fat (SNF) content of milk is necessary when it is sold for liquid consumption. In most countries, milk offered for sale for liquid consumption must conform to certain legal standards with regard to its total solids content, for example the minimum 3% fat and 8.5% solids-not-fat. The yield of dairy products obtained from milk will depend on the amount of constituents (total solids) present. The greater the amount of fat and protein in milk the greater the yield of cheese and milk with a high fat content gives more butter than milk with a lower fat content (O'Connor, 1994).

Normal cow's milk contains approximately 87.4% water and 12.6% milk solids (Goff, 2010). The solids consists of comprises 3.9% fat, 3.2% protein, 4.6% lactose and 0.9% others like minerals and vitamins (FAO, 1986). The composition of milk is affected by a number of factors including genetic and environmental factors (O'Connor, 1994). The factors responsible for variations in milk composition include breed and individuality of the cow, interval between milking, stage of lactation, age and health status of the cow, feeding regime and completeness of milking (O'Connor, 1994).

The natural composition and Physico-chemical properties of raw milk may change by Adulteration of milk by intentional addition of water or other substances are a common problem in many developing countries. Adulteration is illegal because it alters the natural composition of milk and can introduce harmful bacteria and other dangerous substances into milk. Water adulteration lowers the specific gravity and increases the freezing point of milk. The Normal whole milk specific gravity ranges 1.026 to 1.032 milk collection centers and processors routinely determine the specific gravity of raw milk and reject milk suspected of having been adulterated (Kurwijila, 2006).

Table.1. Average milk chemical composition (%) of different cattle breeds

Breed	Fat	Protein	Lactose	Ash
Zebu	5.6	3.1	4.6	0.71
Ayrshire	3.8	3.4	4.8	0.70
Friesian	3.4	3.2	4.6	0.74
Guernsey	4.9	3.8	4.8	0.75
Jersey	5.1	3.8	4.9	0.75
Shorthorn	3.6	3.4	4.8	0.75

Source (O' Connor , 1995)

2.7. Milk Marketing System in Ethiopia

A marketing system includes all activities involved in the flow of goods from the point of initial production to the ultimate consumer. It involves processing raw materials into final products and then distributing them to the consumer (Winrock, 1989).As is common in other African countries (e.g., Kenya and Uganda), dairy products in Ethiopia are channeled to consumers through both formal and informal dairy marketing systems (Mohammed *et al*., 2004).According to CSA (2010), only 6.8 percent of the total milk produced is marketed and milk and milk products are distributed both informally and formally. The formal milk market appears to be expanding during the last decade with the private sector leading the dairy processing industry in Addis Ababa and other major regional towns. However, the share of milk sold in the formal market in Ethiopia (two percent) is much less than that sold in neighboring countries: 15 percent in Kenya and five percent in Uganda (Muriuki and Thorpe, 2001).Formal marketing system milk is collected at the cooperative or private milk collection centers and transported to processing plants. In this system, milk quality tests (principally acidity using alcohol and clot-on-boiling test, and density) are performed on delivery, thereby assuring the quality of milk. This has encouraged the producers to improve the hygiene conditions, storage and transportation of the milk in order to avoid rejection of the product on delivery to the collection centre (Zelalem, 2010).

Informal marketing which involves direct delivery of fresh milk by producers to consumer in the immediate neighborhood and sale to itinerant traders or individuals in nearby towns. In the informal market, milk may pass from producers to consumers directly or it may pass through two or more market agents. About 95 percent of the marketed milk at national level is channeled through the informal system. In this marketing system, milk and milk products may pass from producers to consumers directly or through one or more market agents. Producers sell the surplus milk produced to their neighbors and/or in the local markets (O'Connor, 1994).This system is characterized by no license to operate, low cost of operation, high producer prices as compared with formal market and no regulation of operation (SNV, 2008). The hygienic condition of milk and milk products channeled through this system is also poor. This is mainly due to the prevailing situation where producers have limited knowledge of dairy product handling coupled with the inadequacy of dairy infrastructure such as cooling facilities and unavailability of clean water in the production areas (Zelalem, 2010).

3. MATERIALS AND METHODS

3.1. Description of the Study Areas

The study was conducted in Adea Berga and Ejerie districts of west Shoa zone which were the intervention areas of 'LIVES' project (Figure 1).

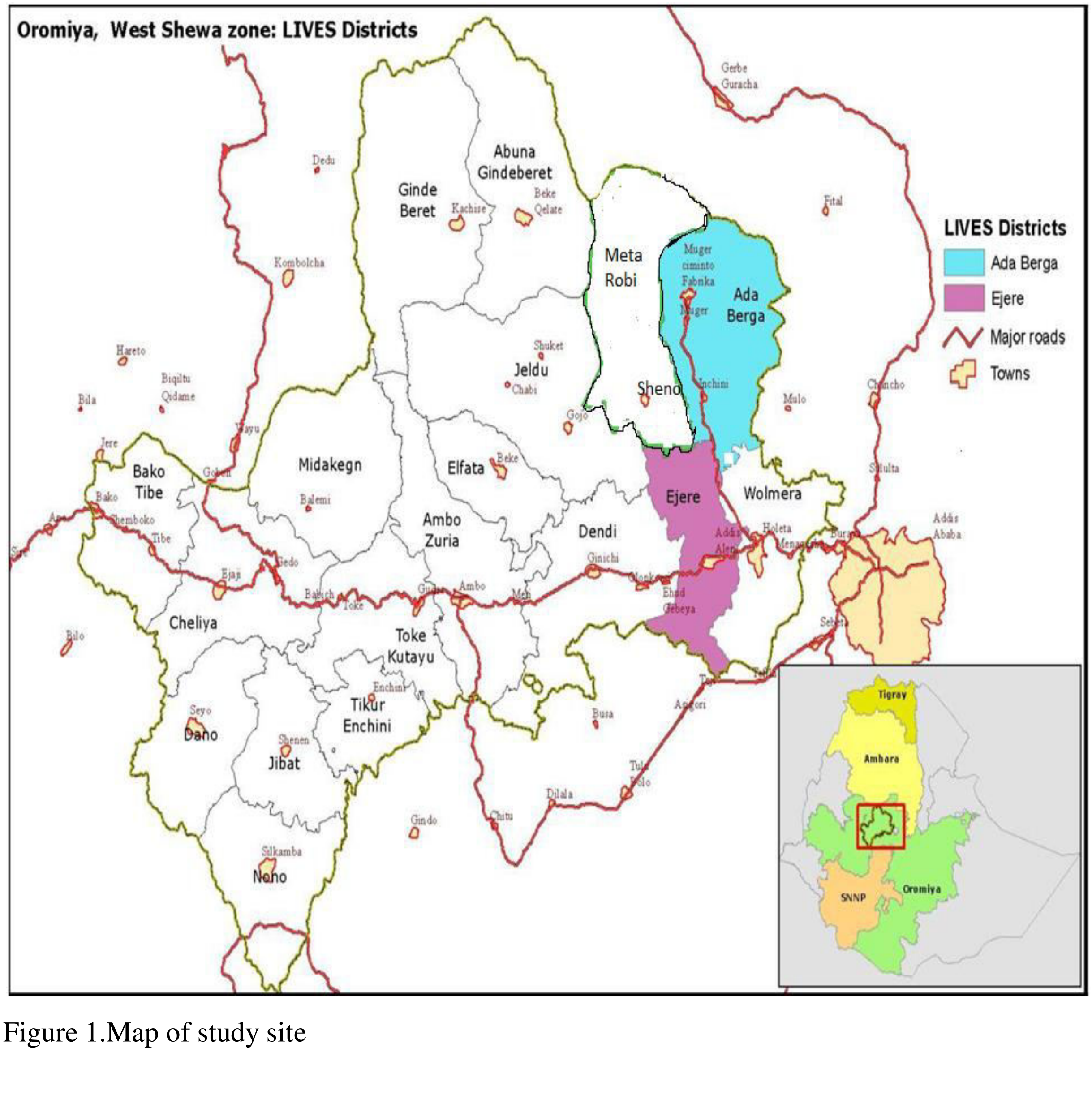


Figure 1.Map of study site

Adea Berga and Ejerie Districts are located in West Shoa zone of Oromia Regional State. Adea Berga district Borderd With; Walmera in the South, Ejerie in the South West, Meta Robi in West and Muger River in the North and East. The town of Adea berga is Enchini. Ejerie district is bordered with, South Wes Shoa Zone in South, Dendi in the West, Jeldu in North West, Meta Robi in the North, Adea berga in the North East and Walmera in East. The town of Ejerie is Addis Alem

Topographically the study areas were mainly characterized with leveled fields that make an ideal place for Agricultural activities. There are three main drainage basins in the areas; Abay, Ghibe and Awash. In addition there was high potential for ground water and smaller rivers like Berga Abay river basin. Adea Berga and Ejerie districts altitude the range of 1166 -3238 and 1872-2631 meters above sea level, rain fall condition ranges 887-1107mm and 991-1194mm and temperature ranges 11-21^{0}C and 14-18^{0}C, respectively.

Agriculture provides the largest share to the livelihood of the zonal population in the region. Although, the study areas were ideal place for market oriented crop and livestock commodity development as it endowed with resources necessary for production and have good access to urban markets.

3.2. Sampling Techniques and Data Collection

3.2.1. Sampling techniques

Livestock and Irrigation Value Chains for Ethiopian Small holders (LIVES) project selected in among 18 non Agricultural Growth Program (AGP) districts three of them ranked and selected in different commodities such as honey and bee wax, milk and butter, small ruminant and irrigated Agriculture. The districts were selected based on their potential, suitability for market oriented Agriculture development, clusters and infrastructure accessibility to move from one district to another (LIVES, 2012). For this study two districts were selected based on their milk production potential then, two kebeles were selected from each district based on availability of dairy cooperatives and existence of milk producing farmers through purposive sampling techniques. Local and cross breed dairy cow owners and consumers were selected by simple random sampling techniques. Dairy cooperatives and processors were selected purposively based on active milk producer members and high volume of milk collection capacity. Only one union was found the study area and selected without any criteria. Finally a total of 180 household milk producers, two primary dairy cooperatives, one dairy cooperative union, two milk processing industries, and ten consumers were interviewed.

Table.2. Sampling layout survey work

Fluid milk chains	Location	Name of kebeles/cooperatives/union/ Processors	Number of samples
	Adea Beraga	Bishan Dimo	45
		Maru Chebot	45
Small holder farmers	Ejerie	Chiri	45
		Iluwaga	45
Cooperatives	Adea Berga	Maru Chebot (Telila Berga)	1
	Ejerie	Chiri (Bruh Tesfa)	1
Union	Holleta	Biftu Berga dairy cooperative union	1
Milk Processors	Addis Ababa	Shola and Berta milk processors	2
Consumers	Holleta		10
Total			195

Laboratory work and preliminary quality tests: Milk samples were collected for alcohol test, clot-on-boiling test; chemical composition and microbial analysis to determine the quality of raw milk. A Total of 90 milk samples were collected from small holder farmers and value chain actors.

Table 3 Sampling Layout laboratory work and preliminary quality tests

Fluid milk Chains	Location	kebeles/cooperatives/ union/processor	Milk sample sources	Number of samples
		Bishan Dimo	at farm gate	10
	Adea Berga	Maru Chebot	at farm and coop gate	20
Smallholder		Chiri	at farm and coop gate	20
farmers	Ejerie	Iluwaga	At farm gate	10
Cooperatives	Adea Berga	Maru Chebot (Telila Berga)	Bulked	6
	Ejerie	Chiri (Bruh Tesfa)	Bulked	6
Union	Holleta	Biftu Berga union	Bulked	6
Milk Processor	Addis Ababa	Berta milk processor	Bulked	6
Consumers	Holleta	Holleta	Bulked	6
Total				90

Coop= cooperatives

3.2.2. Data collection

Two survey tools were employed in order to collect the required information *i.e.* individual interview and group discussion. Semi-structured questionnaire format was used to collect data from smallholder produces focused on the hygienic handling practices during milk production (barn type and cleaning practices, source of water used for cleaning purpose *i.e.* udder, milker and milk utensils), type of storage container and transportation, marketing systems, quality testing methods and other related data were collected (Annex I). Independent questionnaires also used for data were collected from dairy cooperatives, union, individual collectors and processors (Annex II). Secondary data were collected from different sources, such as LIVES zonal report; district livestock agency, dairy cooperatives and dairy cooperative union.

Following individual interview, focus group discussions was employed to validate the information gathered and to get in-depth information on milk production, hygienic practices, and marketing and milk quality constraints in each of the study sites. A focused group discussion was carried out with a group of seven smallholder dairy farmers, one dairy cooperative management staff, two districts and kebele livestock Agency experts from each district, a total of ten individuals (7 males and 3 females) were involved.

Milk samples were collected from individual smallholder farmer's storage container at farm gate and primary dairy cooperatives before added to pool milk and from the bulked milk of primary dairy cooperatives; dairy cooperative union; dairy processor and consumer's storage containers. All milk samples were collected in pre sterilized bottle, properly labeled, stoppered and transported to the laboratory in an ice packed cooler box. Microbial analysis was performed within 24 hours after sampling (HPA, 2003).

Chemical composition: Physico-chemical properties of milk samples fat content, total solid (TS), protein, and density were determined with calibrated milk analyzer (lactoscan).

Coliform Counts (CC): 1 ml of milk sample was added into sterile test tube having 9 ml peptone water. Appropriate decimal dilutions of milk samples were pour-plated on 15-20 ml Violet Red Bile Agar solution (VRBA). After thoroughly mixing, the plated sample was allowed to solidify. Then Petri dishes were incubated at 30°C for 24 hours and counts were made on typical dark red colonies normally measuring at least 0.5 mm in diameter on uncrowned plates (Marth, 1978).

Total Bacteria Count (TBC): 1 ml of milk sample was added into sterile test tube having 9 ml peptone water. Appropriate decimal dilution of milk samples were pour-plated on 15-20 ml SPCA (standard plate count agar) solution and mixed thoroughly. The plated sample was allowed to solidify and then incubated at30°C for 48 h. Colony counts were made using colony counter (Marth, 1978).

Alcohol Test: Five ml of milk and 5 ml of 68 percent alcohol (ethanol) were placed in a test tube. The test tube was inverted several times with the thumb held tightly over the open end of the tube. Then the tube examined for formation of curd particles (O' Connor, 1994).

Clot-On-Boiling Test: Clot-on-boiling test was carried out by placing about five ml of milk in a test tube and then it was placed in a boiling water bath for five minutes. Finally; the test tube was carefully removed from the water bath and examined for the presence of floccules (O'Connor 1994).

3.3. Method of Data Analysis

The quantitative and qualitative data were summarized on Microsoft excel sheet and analyzed using descriptive statistics (mean and percentage) by using SPSS (statistical package for social science, version 20). The total bacteria and coli form count data was transformed to log values before subjected to statistical analysis. The log transformed values were analyzed using the General Linear Model (GLM) for least square mean in Statistical Analysis Software (SAS) version 9.0 (2004). Duncan multiple Range test mean (DMRT) comparisons were used to see the mean difference between sampling sources.

4. RESULTS AND DISCUSSION

4.1. Household Characteristics

The overall mean male and female headed households were 97% and 3% , respectively (Table 4).The highest proportion of the respondents age were ranged16-60 years which accounts about 78.3% while the rest of the respondents were above 60 years which holds 21.7 in the study sites (Table 4). The respondents in the study area had different educational status. Nearly half of the respondents (42.2%) were able to read and write, whereas about 20% received elementary education. The remaining (36.7%) of the respondents have never been in school (Table 4). Substantial proportions of respondents in the study area were not educated; and could be identified as challenge for adoption of new technology for in the development of dairy sector in the study area.

Table 4. Sex, Age and Educational Status of respondents

	Ejerie (n=90)		Adea Berga (n=90).		Overall mean Total=180	
Variables Category	N	%	N	%	N	%
Sex of Family Head						
Male	87	96.7	88	97.8	175	97.2
Female	3	3.3	2	2.2	5	2.8
Age Category HHH						
16-60	73	81	68	75.6	141	78.3
Above 60	17	19	22	24.4	39	21.7
Education Level HHH						
Illiterate	25	27.8	41	45.5	66	36.7
Read and write	43	47.8	33	36.7	76	42.2
Elementary	20	22.2	16	17.8	36	20
12 grade completed	2	2.2	-	-	2	1.1

HHH=house hold head

4.2. Milk production

The overall average amount of milk produced by local breed cows was 1.4 litter /day for 180 days of lactation. The improved cows produced 11 litter /day for 263 days of lactation length (Table 5). The current result similar with Getu *et al* (2009) who reported crossbred cows 11.9 litter/day for 270 days lactation length and in terms of milk yield this result was much lower than milk produced from local cows 2.5 litter/day for 180 days lactation length in Wolmera district. These results were also lower than the overall average lactation lengths of local and crossbred cows were 9.8 and 10.1months, respectively in Burie district (Adebabay, 2009)

Table.5. Milk yield and lactation length of local and improved breed cows

Variables	Ejerie	Adea Berga	Overall Mean
Milk yield(L/day)			
Local	1.5	1.25	1.4
Improved	12	10	11
Lactation length per year			
Local	195	165	180
Improved	270	255	263

4.3. The Hygienic Handling Practices during Milking

4.3.1. Type of housing and cleaning practices

All of the farmers in the study areas were used housed type barn for their cows and milking in the house (Table 6). Zelalem (2010) reported similar result 80.4% of the respondents were used house type barn in central highland of Ethiopia. Godferey (2013) farmers milking in open air exposure to contaminants enter from the environment. Mbabazi (2005) also who reported farmers milked their animals from undesignated poorly maintained milking shades/parlors predisposing milk to contamination and spoilage.

Maintaining the sanitary condition of milking area is important prerequisite for clean milk production (Zelalem, 2010). Most of the respondents 65% removed manure daily While 35% were removed three times a week (Table 6). Abebe *et al.* (2012) who reported similar results about 47% of the respondents clean their barn three times a week in Gurage Zone, Ezha district.

Table.6. Types of housing and barn cleaning frequency

Variables	Ejerie (N=90)		Adea Berga (N=90)		Total (N=180)	
	N	%	N	%	N	%
Type of housing						
Housed	90	100	90	100	180	100
Barn cleaning Frequency						
Daily	63	70	54	60	117	65
Three times a week	27	30	36	40	63	35

4.3.2. Hygienic condition of cows and milker

The milker can be an important source of milk contamination. Therefore, keeping good personal hygiene and milkers should be in good health during milking operation (Zelalem, 2010). Most of the interviewed dairy producers (69.4%) washed their hands before milking while the rest 30.6% did not wash their hands (Table 7). Milk producers and milk collectors in the study areas did not cover their hair and dressing gown during milk collection.

Cleaning of the udder of cows before milking is one of the most important hygienic practices required to ensure clean milk production. This is important since the udder of the milking cows could have direct contact with the ground, urine, dung and feed refusals (Zelalem, 2010). As observed in this study, 62.2% of the dairy producers washed their cow's udder before milking and 37.8% were not washing (Table 7) and simply allowed their calves to suckle before milking. Calf suckles and milking follows without cleaning the teats, Saliva from the calf mouth and unwashed teats increase bacterial counts (Kurwijila, 1989).The current result was lower than Haile *et al.* (2012) reported that 82.5% of the small size farm owning households in Hawassa city practice pre milking udder washing. Contrary to this result Abebe *et al.* (2012) who reported that all respondents did not use udder washing before milking in Gurage Zone, Ezha district.

The use of individual towel and following essential cleaning practices during milking is important for the production of quality milk (Zelalem, 2010). However, about 46.7% of the smallholder households did not use towels for udder drying, 15.6% used common towel and 37.7 % reported they did not practice udder drying (Table7). Milking in dry condition significantly reduces bacterial count. It is because no surplus water remains in the surface of the udder to drip into the milk and due to less chance of leaching dirt and bacteria from udder, teats and hands into milk (Islam *et al*., 2009) .Wallace (2009) reported that thorough cleaning of the udder followed by drying with a clean cloth was effective in reducing the number of bacteria in milk contributed from soiled teats.

Table 7: Hygienic condition of cows and milker

	Ejerie (n=90)		Adeaberga (n=90)		Total (n=180)	
Variables	N	%	N	%	N	%
Hand washing						
Before milking	68	75.6	57	63.3	125	69.4
No washing	22	24.4	33	36.7	55	30.6
Udder washing						
Before milking	64	71	48	53.3	112	62.2
No washing	26	28.9	42	46.7	68	37.8
Towel used for udder drying						
Common towel	20	22.2	8	8.9	28	15.6
Just with hands	44	48.9	40	44.4	84	46.7
No washing and drying	26	28.9	42	46.7	68	37.8

4.3.3. Type of milking container and sanitary practices

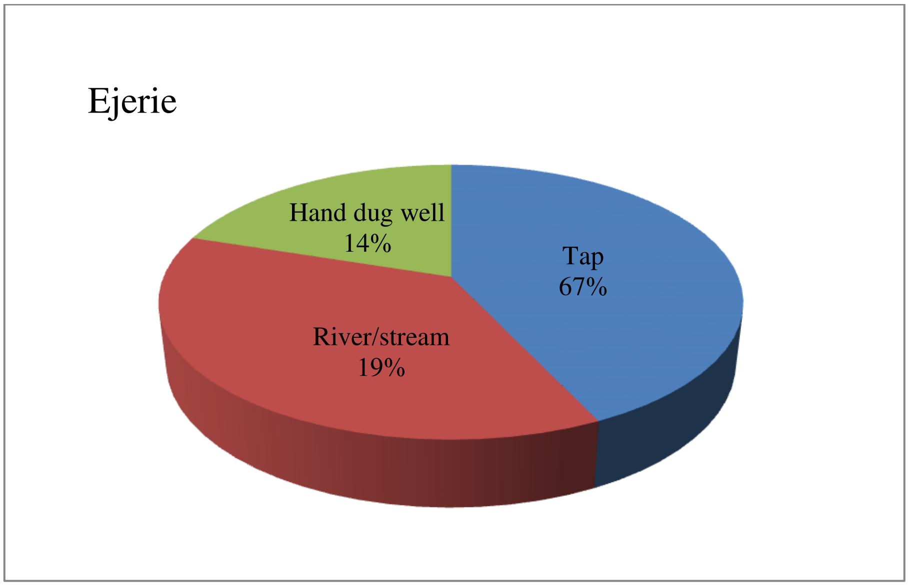
All of the interviewed milk producer farmers were used plastic made milk containers during milking and transported the milk to collection centers (Table 8). Abebe *et al.* (2013) reported similar result in Ezha district of Gurage Zone where all farmers used plastic jars as milking utensil. Dairy cooperatives, Dairy cooperative union and processors used aluminum container for milk transportation and storage. Milk containers such as non-food grade plastic cans, buckets and jerry cans are not recommended in the production of clean milk (Kurwijila, 2006). Aluminum containers are recommended because they don't have adhesive properties and therefore easy to clean when compared with plastic containers (Karuga, 2009). Milking and milk storage utensils are properly cleaned and maintained. Therefore, cleaning and disinfections of equipment after each milking is important for reduction of milk contamination from the equipment (Murphy, 1996). Producers should pay particular attention for the type as well as cleanliness of milk equipment. In the present study, almost all of the dairy producers 98 % and milk collectors washed milking utensils after every use (Table 8). In Ejerie district 3.3% of smallholder dairy producers were cleaned their milking utensil before and after usage. About 77% of the respondent washed their milk container with cold water and soap while 23% used hot water and soap (Table 8). The current finding contradicts with the finding of Haile *et al.* (2012) who reported about 85.6% of the producers used warm water together with detergents to wash milk handling equipment while 12.1% of them cleaned with cold water. All milk processing industries and dairy cooperative union were cleaned their milking equipments with warm water and liquid detergents. All primary dairy cooperatives and 70 % of consumers were washed their milk container with cold water and soap. Only 30% of the interviewed consumers were washed their milk utensils with warm water and soap.

Table 8 Milking container and sanitary practices

	Ejerie (n=90)		Adea Berga (n=90)		Total (n=180)	
Variables	N	%	N	%	N	%
Milk utensils used for milking						
Plastic	90	100	90	100	150	100
Cleaning frequency of milk utensils						
Before and after every use	3	3.3	-	-	3	2
after every use	87	96.7	90	100	177	98
Washing of milk Equipments						
Cold water and soap	64	71	74	82	138	77
Warm water and soap	26	29	16	18	42	23

4.3.4. Source of water used for cleaning

For production of quality milk a good supply of clean water is essential. Water used for washing and rinsing milk equipments and containers during milk handling must be the same safety and purity as drinking water (Younan *et al.*, 2007).Smallholder producers in Ejerie and Adea Berga districts used different water sources for cleaning purpose *i,e* tap water (67%, 43%), river (19%, 37%) and Hand dug well (14%, 20%), respectively. Water from non tap sources used for different purposes can definitely contribute to poor quality milk and milk products. Therefore, it is important that producers should at least filter and heat treat it before use (Zelalem, 2010). Jay (1992) also reported high colony counts recorded on farms using wells as a water source. In Ejerie district better tap water accessibility than Adea Berga. Dairy cooperatives, union, processors and consumers were used tap water for cleaning.



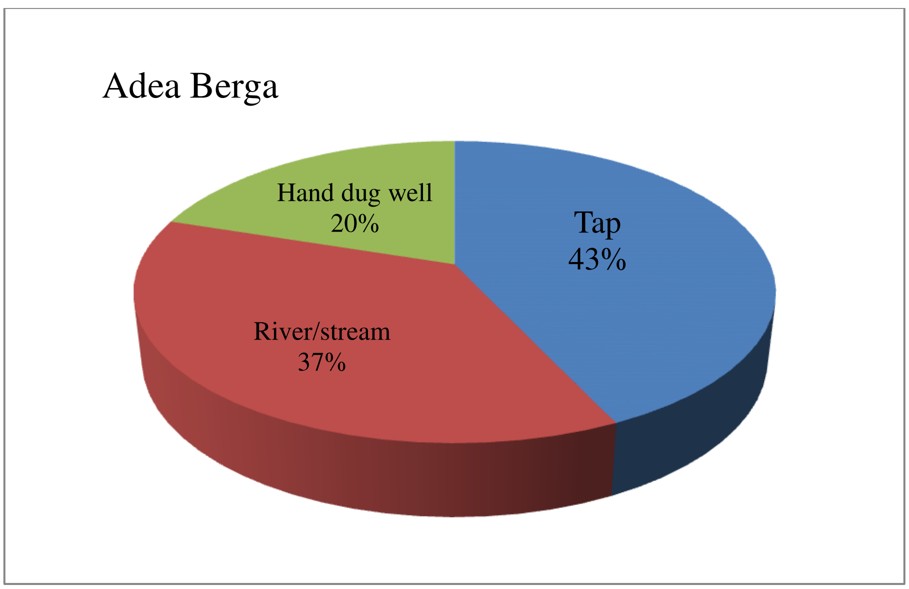


Figure 2 Ejerie and Adea Berga Water sources

4.4. Cooling System and Transportation

After milking proper milk cooling method is essential to maintain the quality of milk. All producers used traditional cooling method (put raw milk in cold water bath) and transported their milk on foot. Dairy cooperatives and unions did not have cooling facilities for raw milk during collection, storage and transportation to processing plant. Dairy cooperative union used refrigerators to preserve milk products (cheese and butter). Milk processor and dairy cooperative union used vehicles for milk collection and transportation. The vehicles were not appropriate for raw milk transportation because its lacks cooling facilities.

4.5. Preliminary Quality Tests

4.5.1. Alcohol and clot-on-boiling tests

The total collected milk samples 32.2% were positive with alcohol and 18.8 % were positive with clot-on-boiling testes (Table 9). These observations support the view that the alcohol test is more sensitive than the clot-on-boiling test as reported by O'Connor (1994). Similarly, Zelalem (2010) reported 21% milk samples checked with alcohol test were positive, while only 14% of the samples were positive for clot-on-boiling test in the central highland of Ethiopia. Asamnew (2010) also reported 51% of smallholder and dairy cooperatives milk sample clot by alcohol test and 23% clot on boiling test in Bahirdar zuria and Mecha district. Milk samples collected from dairy cooperatives, unions, processors and consumers had high value on both tests as compared to milk samples collected from individual farmers at farm and cooperative gate. Ejerie and Adea Berg districts were at farm gate negative in clot- on- boiling test and very minimum numbers of samples were clotted on alcohol test.

Table 9 Alcohol and Clot –On-Boiling Tests in the Study Areas

Location	Milk sources	N	Positive Results in percents (%)	
			Alcohol	Clot-on-Boiling Test
	At farm gate	20	10	-
Ejerie	At coop gate	10	20	10
	Bulked milk at coop	6	33.3	16.7
	At farm gate	20	15	-
Adea Berga	At coop gate	10	30	30
	Bulked milk at coop	6	50	33.7
Holleta	Dairy coop union	6	66.7	50
Addis Ababa	Processors	6	83.3	50
Holleta	Consumers	6	83.3	66.7
Overall mean		90	32.2	18.8

N= number of milk samples

4.6. Microbial Quality and Chemical Composition

4.6.1. Microbial quality of raw whole milk

The overall all average total bacteria count (TBC) and coliform count (CC) of raw whole milk were 6.98 and 4.84 log cfu/ml, respectively (Table 10). The total bacteria and coliform counts were significantly different ($P<0.05$) among different milk sources (Table 10). The overall mean total bacterial count of raw milk produced in the study area was 6.98 log cfu/ ml. This value is much higher than the acceptable value of 1 x 10^5 bacteria per ml of raw milk (O'Connor, 1994). This high level of contamination of milk might be due to initial contamination originating from the udder surface, quality of cleaning water, milking utensils. Therefore, total bacterial count is a good indicator for monitoring the sanitary conditions practiced during production and handling of raw milk (Chambers, 2002). A good instance worth mentioning was reduced total bacterial count observed in milk sampled from farmers who received training on hygienic milk production and handling, and who used recommended milk containers as compared to that produced by the traditional milk producers (Rahel, 2008; Sintayehu *et al.*, 2008).

The present result is also comparable with the finding of Fikrineh *et al.* (2012) who reported 7.08 log cfu/ml of TBC in mid Rift valley Ethiopia and lower than the report of Asaminew and Eyassu (2011) who reported 7.58 log cfu/ml of TBC in cow milk sampled from around Bahir Dar and Mecha district. This value is lower than total bacteria count reported by Zelalem (2010) in the central highlands of Ethiopia (9.10 log cfu/ml) and Abebe *et al.* (2012) in Southern Ethiopia (9.82 log cfu/ml). However, there was a significant microbial count difference among sampling sources of milk (Table 10). In Ejerie districts the average total bacteria count in farm gate is significantly lower than bulked milk sample at cooperatives. Moreover, milk samples collected from dairy cooperative on arrival was significantly different with bulked milk at cooperatives. Generally the trend of total bacteria count in the two districts revealed that there was increment from farm gate to milk processing plants (Table 10). This could be due to improper handling, storage and transport facilities after the milk leaves the farm. In case of Adea Berga district the average total bacteria counts of sampled milk in farm gate is significantly lower than both on arrival dairy cooperative and bulked milk at cooperatives. Bulking milk from different farmers were leads to an increased chance of milk contamination.

The overall mean coliform count (CC) of raw milk produced in the study areas were 4.84 log cfu/ml (Table 10). The coliform count obtained in the present study is higher than that reported by Asamnew (2010) who found coliform count of 4.49 logcfu/ml in Bahr dar Zuria and mecha districts. Others also reported lower values Abebe (2012) 4.03 log cfu/ml in Southern Ethiopia and Zelalem (2010) 4.58 log cfu/ml in the central Highland Ethiopia .The higher coliform count observed in the current study it might be attributed to the initial contamination of the milk through the milkers, milk containers and milking environment. Since it is not practical to produce milk that is always free of coliforms, even at high level of hygienic condition; their presence in raw milk to a certain extent may be tolerated. However, the present result was larger than the acceptable limit. Coliform (CC) count less than 100 Colony Forming Units (CFU)/ml is considered acceptable for milk intended to be pasteurized before consumption. Counts of 10 cfu/ml or less are achievable and desirable if raw milk will be consumed directly (Jones and Sumner, 1999; Ruegg, 2003). The average coliform counts of milk collected from farmer gate and upon arrival at the dairy cooperatives are significantly lower than bulked milk at cooperatives. These findings agree with Omore *et al.* (2005) who reported that bacterial counts increase and subsequently, milk quality decreases as milk passes through increasing numbers of intermediaries.

Table 10. Microbial counts of raw milk (LSM ± SE)

Sources of milk	Number of samples	Microbial quality of milk (log cfu/ml)	
		TBC	CC
Ejerie			
Farm gate	20	5.47 ± 0.16^{e}	3.84 ± 0.10^{f}
Coop gate	10	6.73 ± 0.12^{d}	4.46 ± 0.13^{de}
Bulked milk at cooperative	6	7.25 ± 0.27^{cd}	4.86 ± 0.13^{d}
Adea Berga			
Farm gate	20	6.04 ± 0.15^{e}	4.20 ± 0.93^{ef}
Coop gate	10	7.08 ± 0.12^{d}	5.47 ± 0.17^{c}
Bulked milk at coop	6	7.26 ± 0.27^{cd}	5.90 ± 0.17^{b}
Bulked milk at unions	6	7.80 ± 0.27^{c}	5.96 ± 0.17^{b}
Bulked milk at processor	6	9.75 ± 0.27^{b}	6.02 ± 0.17^{b}
Consumers	10	10.69 ± 0.27^{a}	6.64 ± 0.17^{a}
Overall Mean	90	6.98 ± 0.17	4.84 ± 0.10

Means with different superscripts letters are significantly different (P<0.05)

4.6.2. Major chemical composition

The overall average contents of fat, protein and total Solid contents of raw whole milk were 3.5, 3.09 and 12.19, respectively (Table 11). There was a significant difference ($P<0.05$) in the average fat content of raw whole milk between the two districts. The highest milk fat content value was recorded at Adea Berga district 3.9% (Table 11). The average fat content of raw whole milk observed in the current study is much less than values reported earlier. Rahel (2008), for instance, reported 5.35% fat for zebu cows in Delbo area of Wollayta zone and Alganesh (2002) indicated the value to 6.1% for Horro breed in Eastern Wollega. This might be due to the variation in milk fat content among genetically different breeds of cows and also for the different stages of lactation. The average protein and SNF content of milk as observed in the current study was 3.09 and 12.19 %, respectively (Table 11). The values obtained in the present study are consistent with that reported by Zelalem (2010) and Rahel (2008) for milk samples collected from smallholder farmers in Delbo area of Wollayta zone and central highlands of Ethiopia, respectively. Similarly, Alganesh (2002) also reported similar 3.31% protein content for milk samples collected from smallholder producers in East Wollega.

Table 11 Chemical composition of raw milk (LSM ± SE)

Milk sampling sources	N	Variables		
		Fat	Protein	Total solid
Ejerie				
Farm gate	20	$3.59±0.06^{b}$	3.10±0.03	12.41±0.32
Coop gate	10	$3.42±0.09^{bc}$	3.09±0.04	12.26±0.25
Bulked milk at coop	6	$3.37±0.11^{bc}$	3.09±0.03	12.08±0.43
Adea Berga				
Farm gate	20	$3.94±0.07^{a}$	3.14±0.02	12.47±0.24
Cooperative gate	10	$3.40±0.08^{bc}$	3.09±0.04	12.22±0.32
Bulked milk at coop	6	$3.33±0.11^{bc}$	3.08±0.03	11.86±0.43
Bulked milk at unions	6	$3.30±0.11^{bc}$	3.08±0.02	11.99±0.43
Bulked milk at processor	6	$3.30±0.11^{bc}$	3.07±0.04	11.75±0.45
Consumers	10	$3.20±0.11^{c}$	3..07±0.04	11.75±0.45
Over all mean	90	3.52±0.38	3.09±0.10	12.19±0.10

Means with different superscripts letters are significantly different (P<0.05)

N= number of samples Coop=Cooperative

Specific gravity: The value of specific gravity of milk sample from small holder producers at cooperative before added to pool milk the values were in the range of 1.024 to 1.032 (Ejerie) and 1.022 to 1.031 (Adea Berga) districts respectively (Table 12). The normal specific gravity of milk ranges from 1.026 to 1.032 (Kurwijila, 2006). However the milk collection centers accepted 1.027 as normal parameters for specific gravity of milk. The current result indicate that about 85% of Ejerie and 65% of Adea Berga milk samples were within the acceptable range of unadulterated milk while the rest 15 % and 35 % of the samples falls below the standard and this result shows that milk was mostly adulterated with water in Adea berga district compared to Ejerie district. Milk at normal state, have unique physico-chemical properties, which are used as quality indicators. The density of milk was commonly used for quality test mainly to check for the addition of water to milk or removal of cream. Addition of water to milk reduces milk density, while removal of cream increases it (O'Connor, 1994).

Similar to current study Alehegne (2004) reported specific gravity ranging from 1.025 to 1.029 for Small holder dairy Farms in Debre Zeit. Zelalem (2010) reported that majority raw whole milk sample collected from Holetta and Selale area their specific gravity were fall within the range between 1.028 and 1.032.

Table 12 Specific gravity test in the Study Areas

Location	Milk sources	N	Specific gravity (g/ml) Minimum	Maximum
Ejerie	At farm gate	20	1.028	1.032
	At coop gate	10	1.024	1.032
	Bulked milk at coop	6	1.024	1.030
Adea Berga	At farm gate	20	1.027	1.031
	At coop gate	10	1.022	1.031
	Bulked milk at coop	6	1.021	1.028
Holleta	Dairy coop union	6	1.020	1.028
Addis Ababa	Processor	6	1.025	1.027
Holleta	Consumers	10	1.020	1.027

N= number of milk samples Coop= Cooperative

4.7. Fluid Milk Marketing System

4.7.1. Milk marketing channels and outlets

Marketing channels are routes through which products pass as they are moved from the farm to the consumer (Winrock, 1989). Marketing outlet is the final market place to deliver the milk product, where it may pass through various channels. In the study area milk was sold for the consumers through tracing of different channels and outlets.

Producer-consumer (P-C)

Producer → Dairy cooperatives→ Consumer

Producer → Individual collectors (milk hawkers) →Consumer

Producer → Dairy cooperatives union→ Consumer

Producer→ dairy processors →Consumer

Producer →Dairy cooperatives→ dairy cooperative union→ dairy processors→ Consumer

There was different milk marketing channels in the study areas through which smallholder dairy farmers were sold their milk to other market value chain actors. However, about 95% and 47% in Ejerie and Adea Berga districts milk producers follow formal marketing system respectively, In Adea Berga district Bishan Dimo kebeles smallholder farmers were sold their milk for local consumer, hotel, café, and restaurant due to the absences of dairy cooperatives and other milk collectors in the area. This finding have been different from the finding of (Van der Valk and Tessema 2010) who reported that 98% of milk produced in rural area was sold through informal chain whereas only 2% of the milk produced was reached the final consumers through formal chain. Additionally, Girma and Verschurr (2013) reported 35% of the respondents were sold their milk following both informal and formal channels and 25% of the respondent farmers were sold their milk through formal marketing channels. In informal marketing system, smallholder producers, cooperatives, unions and individual milk collectors were sold fluid milk for local consumers, hotels, restaurants, cafes and retailers.

Table 13.Small holder producers sell raw milk for different beneficiaries

	Ejerie (n=90)		Adea Berga (n=90)		Total (n=180)	
Variables	N	%	N	%	N	%
Formal market						
Dairy cooperative and union	68	75.6	42	46.7	110	61
Processors and cooperative	17	19	-	-	17	9.5
Informal market						
Café, restaurant, hotel and retailers consumers	5	5.5	48	53.3	53	29.5

4.7.2. Milk marketing prices

Milk buying and selling price per liter varies between milk value chain actors. Dairy cooperatives and union bought milk from the producers by credits and pay their money every 15 days. Some farmers preferred to sell with cash to Shola milk processing industry. In general the annual buying and selling price of milk ranges 9.25 -11Birr/ liter. The milk price did not decline at fasting season.

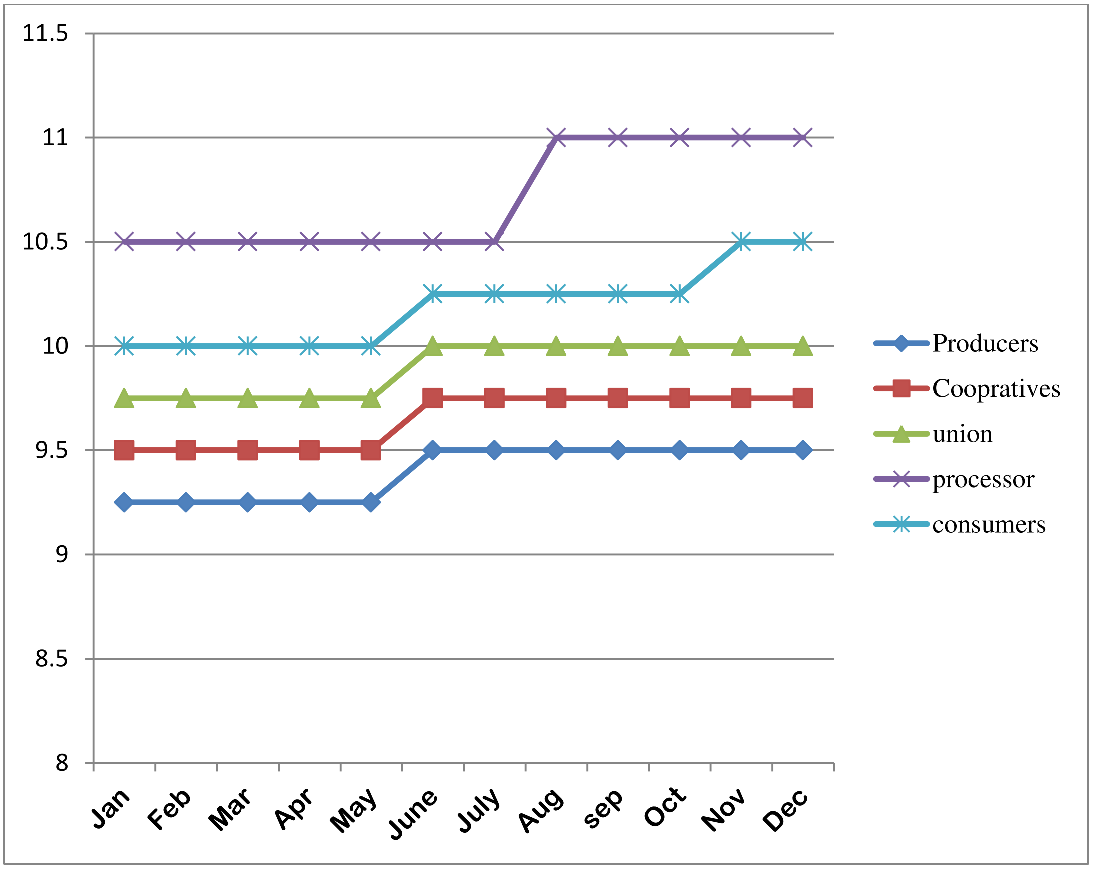


Figure 3 buying and selling price of milk

4.7.3. Milk quality test method during marketing

Primary dairy cooperatives, dairy cooperative union and milk processors tested the quality of milk by using of lactometer and lactoscan. Chemical composition (fat and water) content were the major milk quality criteria to accepted or rejected the milk, If the density and fat content of milk as found below the standard, raw milk was rejected because of some illegal farmer's were added water.

4.8. Major Milk Quality Related Constraints

Milk quality related constraints in the study areas prioritized by the respondents during group discussions were limited awareness on hygienic handling of milk, lack of cooling facility, shortage of clean water , Lack of effective quality control system and absence of quality based payment system. In each study district constraints were ranked in Table (14).

Table 14 Milk quality constraints in the study areas

	Ranked	
Variables	Ejerie	Adea Berga
Limited awareness the hygienic quality of milk	1st	1st
Shortage of clean water	3rd	2nd
Lack of cooling facility	2nd	3rd
Lack of effective quality control system	4th	4th
Absence of quality based payment system	5th	-

5. SUMMARY AND CONCLUSIONS

The study was carried out in Ejerie and Adea Berga districts of west Shoa zone, Oromia Region State of Ethiopia to assess cattle milk quality. The survey works were involved interviews of smallholder milk producers, primary dairy cooperatives, dairy cooperative union, milk processors and consumers in the survey parts which includes: barn type and cleaning practices, hygienic condition of the milker and cows during milk production, source of water used for cleaning purpose fluid milk quality test methods, marketing system and milk quality constraints.

The other parts of the study involved microbial properties and chemical composition of raw milk and milk samples collected from along fluid milk value chain. Alcohol and clot on boiling tests were conducted to determine the freshness and acidity level of raw milk from farm gate up to consumer level. About 32.2% of milk samples were clotted by alcohol test; while 18.8% of the samples were positive to clot-on-boiling test. The density of milk was checked, if milk has been adulterated with added water or solids. The density of normal whole milk range 1.024 to 1.032. In Ejerie 85% and Adea Berga 65% milk samples fall within the acceptable range while the rests fall in below the standards.

The overall mean value of fat, protein and solid-not-fat percents were3.51±0.38, 3.09±0.10 and12.19±0.10, respectively. Fat mean value percentage were significantly different ($P<0.05$) among fluid milk value chain actors. The highest fat mean value recorded in Adea Berga district at farm level (3.94). Overall Mean total bacterial counts and Coliform counts were 6.98±0.17cfu/ml, 4.84±0.10 log cfu/ml and significantly different ($P<0.05$) among different sampling sources. The highest coliforms (6.04cfu/ml) and total bacterial count (10.69cfu/ml).were observed at consumer level.

The major milk quality constraints in the study areas were limited awareness on hygienic handling of milk during milk production, shortage of clean water for sanitation purpose, lack of cooling facilities during storage and transportation, lack of effective quality control system and absence of quality based payment system.

The present study showed that the Total bacterial count (TBC), Coliform cunt (CC) and lactic acid percents were increases milk flows from producer to consumers. Microbial counts were not meet the international acceptable limit. This indicates that milk production and handling practices under poor hygienic condition due to inappropriate utensils used for milking, shortage of clean water for sanitation purpose, lack of cooling facilities during storage and transportation. Additionally the survey and laboratory results were show that in the two districts same small holder milk producing farmers were adulterated raw milk with water and removed the cream. This illegal practice was contribute to milk quality deterioration and reduced the standard milk composition.

The following recommendations were forwarded to improve milk Quality

- Trainings should be given for small holder dairy farmers in milk handling and hygienic practices.
- Awareness creations needed for among primary dairy cooperatives, dairy cooperative union, milk processors and individual collectors about the hygienic production, handling and processing of milk and milk products and the importance of raw milk quality control and safety.
- If water source is not potable, it should be heat treated for washing udder and milking equipments
- Efficient milk cooling system is required at producer and milk collectors' level.
  During milk transportation vehicles used to transport should be equipped with cooling facilities.
- All milk collectors should be regularly control the quality of milk and Quality based payments introduced for improvement of the quality of milk.

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7. APPENDICES

ANOVA test on chemical composition and microbial Quality of milk

Appendix Table 1: ANOVA Test on fat content

Dependent Variable: FAT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	8	5.14069192	0.64258649	7.84	<.0001
Error	81	6.64155808	0.08199454		
Corrected Total	89	11.78225000			

R-Square	Coeff Var	Root MSE	FAT Mean
0.436308	8.146427	0.286347	3.515000

Appendix Table 2: ANOVA Test on Protein content

Dependent Variable: Protein

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
treatment	8	0.05171005	0.00646376	0.61	0.7631
Error	81	0.85180551	0.01051612		
Corrected Total	89	0.90351556			

R-Square	Coeff Var	Root MSE	Protein Mean
0.057232	3.309902	0.102548	3.098222

Appendix Table 3: ANOVA Test on SNF content

Dependent Variable: SNF

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatments	8	5.14596949	0.64324619	0.58	0.7952
Error	81	90.54140939	1.11779518		
Corrected Total	89	95.68737889			

R-Square	Coeff Var	Root MSE	SNF Mean
0.053779	8.667394	1.057258	12.19811

Appendix Table 4: ANOVA Test on TBC

Dependent Variable: TBC

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatments	8	192.5409534	24.0676192	55.25	<.0001
Error	81	35.2847588	0.4356143		
Corrected Total	89	227.8257122			

R-Square	Coeff Var	Root MSE	TBC Mean
0.845124	9.453786	0.660011	6.981444

Appendix Table 5 ANOVA Test on CC

Dependent Variable: CC

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	8	72.01756116	9.00219515	51.56	<.0001
Error	81	14.14352884	0.17461147		
Corrected Total	89	86.16109000			

R-Square	Coeff Var	Root MSE	CC Mean
0.835848	8.628234	0.417865	4.843000

Questioner 1.Household interview

This questioner is for the purpose of milk quality assessments, therefore I would like to Acknowledge you that your good cooperation by providing true information.

I. General

1. Zone: ______________________________

2. District (Woreda): ____________________

3. Site/town: ____

4. Farmer/owner name: ____

5. Gender of the owner: A. Male B. Female

6. Age of the owner: ____

7. Educational level of the owner

1. Illiterate 2. Write and read 3. Primary education (1-8)

4.10th grad complete 5.12 grade completed 6. Other (specify) ___________

_I. milk yield and lactation length

1. What is average daily milk yield per cow in your farm?

A. pure exotic: __________________L/kg

B. zebu: ________________________L/kg

C. crossbred: ___________________L/kg

2 What is the lactation length for?

A. Pure exotic cows: ______________ months

B. Zebu cows: ___________________ months

II Housing and cleaning practices

1. What type of barn do you own?

1. housed 2. Fenced 3. No barn

2. How frequent do you clean your cow's house/barn?

1. Daily 2. Two times a week 3.Three time's aweek 4. Once a week 5. Do not clean

6. Other comments (indicate) _____________

III. Hygienic practices during milking

1. Do you wash your hands before milking? (1)Yes……….. (2)No…………………

2. Do you wash your cow's udder before milking? (1) Yes….. (2) No……..

If yes, when do you wash it?

(1) Cleaned before milking only (2) cleaned after milking only (3) cleaned before and after milking

3. If you wash the udder what materials do you use for drying?

1. Collective towel 2. Individual towel 3. Just with hands 4. Others (specify)

4. What is the source of the water used for washing the udder and milk utensils?

1. Piped/ tap…… 2.River/ stream 3. Hand dug well 4. Other (specify)…………

5. What type of milk container do you use?

1. Plastic……………… 2.Aluminum………………… 3.Other……………………

6. How often do you wash the container?

1. before every use 2. After every use 3. Before and after every use

7. how do you clean the container

1,cold water 2.hot water 3.cold water and soap 4.hot water and soap 5.detergent and water

IV. Milking technique and marketing system.

1. Milking procedure used:

1. Hand 2. Machine3. Both

2. Milking frequency per day:

1. Once 2. Twice3. Three or more times ____________

3. Do you cool the milk before sale? 1. Yes____ 2, No____

If yes how?

1. Refrigerator 2. Traditional cooling system 3. If others _______

4. Do you transport your products to market places? 1. yes 2. No

5. If YES, what is the means of transportation?

1. on foot, 2. horse cart, 3. on animal back, 4. Public transport, 5. Private car, 6. other means (specify)______________________

6 Where do you sell your milk?

1. Dairy cooperatives and union 2. Milk Processors and cooperatives 3. café, restaurant and hotels 4. Individual collectors 5.Other (specify) ___________________

7. Do the workers at collecting centers test the quality of milk before adding to the pool?

1, Yes 2, No

8. If YES, indicate method of quality test and criteria use

1. Alcohol test 2. Density test 3. Clot on boiling test 4. lactoscan 5. Other (Specify)

9. Has your milk been rejected by the cooperative? (1)Yes…. (2)No……

If yes, why was it rejected?

1. Low fat 2 . Abnormal color 3.Failed Alcohol test 7. Other (Specify)

4. Low Density 5. Abnormal smell 6= Dirt

10. What is the selling price milk in birr per letter different seasons/months of the year?

Average selling price per liter/kg											
Sep	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Au

11. Any comment that you want to make concerning milk quality and marketing

____

____

____

____

____

____

Questioner 2: Milk collection centers

I. General information

Region____

Zone: ____

Name of the cooperative/union/processors/Indivcollectors ________________________

Name of the respondent: _______________________________________

Position/responsibility of the respondent: ________________________

Date: ____

II. Milk Collection and distribution

1. Where do you get your milk?

1= Rural producer 2= Urban and peri-urban producer 3. Other collectors

4. Other, specify_______________________________________

2. How many litters of milk do you collect per day?

1. Morning _________lit 2. Evening ____________lit

3. What time do you collect milk?

1. Morning 2 Evening

4. What type of transportation means you use to transport the collected milk?

1. Bicycle 2. Cart 3. Donkey 4. Vehicle 5. Other, specify_____________

5. Do you have cooling facility?

1= Yes 2= No

6.If yes, what type of cooling facility you have and capacity?

1= Bulk tank cooler 2. Refrigerator 3. Ice box 5= Cold truck 6. Other, specify

7. What type of utensils does the collection center use

1. Stainless steel 2. Clay 3.Almunium 4. Plastic 5. Others Specify) for:_________________

8. How often do you wash the container?

1.Before every use 2. After every use 3. Before and after every use

9. how do you clean the container

1,cold water 2.hot water 3.cold water and soap 4.hot water and soap 5.detergent and water

10. What is the water source used for cleaning?

1. Tap water 2. Surface water 3. Ground water 4. Rain 5. Others (specify) ___________

11. What quality test does the collection centre use up on milk reception?

1. Milk density/Lactometer/thermometer 2. Alcohol test c. Fat test

3. Acidity test 4.Organoleptic test (smell, taste, texture…) 5. No test g. Others (specify)

12. What is the acceptable limit for the test(s) used at the collection center?

1. Density/Lactometer ______________________

2. Fat test: ____

3. Acidity test: ____

4. Organoleptic test (smell, taste, texture…): ________________

5. No test: ____

6. Others (specify): _____________________________________

13. What is the basis of milk price?

1. Volume/weight of milk 2. Chemical content 3. Microbial load 4. Others (specify): ___

14 . What is the frequency of payment to milk suppliers?

1. On daily basis 2. On weekly basis 3. On monthly basis 4. On yearly basis

5. Others (specify)_______

15. What is the buying price of milk in birr per letter different seasons/months of the year?

Sep	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Au

16. What is the selling price milk in birr per letter different seasons/months of the year?

Average selling price per liter/kg											
Sep	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Au

17. If, you any comments to improve milk quality

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